

4-2-21

76

The great problem in the improvement of the Electric Telephone is to render the amplitude of the electrical undulations as great as possible.

For this purpose it will be necessary
1st to discover that arrangement of coil, magnet and diaphragm which gives the maximum effect -

2^{ndly} to reinforce the sounds at the receiving end of the circuit by some mechanical arrangement and
3^{rdly} to devise some apparatus which when introduced into the circuit between the transmitting and receiving Telephones will increase the amplitude of the electrical undulations.

For the purpose of determining the correct relations between the coil, magnet and diaphragm I have decided to repeat former experiments upon this subject in a more precise and delicate manner.

My method of proceeding is as follows.

A Telephone is connected in circuit with one of

Problem to be solved.

To increase the amplitude of the electrical undulations.

Method of measuring Telephone current.

Sir William Thompson's
Galvanometers and a current
in one direction only is
produced by dropping a weight
upon the diaphragm from a
uniform height. In order
to guard against slight
irregularities in the experiments
the mean of a number of
deflections is taken.

Produce
current in
one direction
by dropping
a weight
upon telephone

I propose to commence
experiments by varying the
coil to determine the best
method of winding the wire.

A straight bar of
magnetised steel was taken
length 6 inches, diameter
 $\frac{1}{4}$ of an inch

Three pieces of insulated
copper wire number 24 were
taken each piece 157 ft in
length. These were made
into coils of different lengths

- No 1 coil 6 inches in length (see fig 1)
- No 2 coil 3 inches in length (see fig 2)
- No 3 coil $\frac{3}{8}$ of an inch in length (see fig 3)

These coils were placed
alternatively upon a magnet
and a piece of iron was
dropped from a height of
one inch upon ^{the south} pole of
the magnet

Effect of
lengthening
coil.

Experiment 1 - With the 6
inch coil the mean def of

Exp 1.

twenty readings gave a deflection of 21.6 . maximum 23 minimum 19 degrees.

Experiment 2. With the 3 inch ^{Exp. 2} coil the mean of 20 readings was 30.5 degrees maximum 40 minimum 20 .

Experiment 3. With the $3/8$ inch ^{Exp. 3} coil a mean of twenty readings gave 31.85 . max 40 min 20 .

Experiment 4. A flat coil ^{Exp. 4} of wire $3/8$ in thick made in America of fine wire number not ascertained gave as a mean of ten readings 64.6 . max 82 . min 60 .

Experiment 5. Another flat ^{Exp. 5} coil of similar dimensions but of exceedingly fine wire made for me in Glasgow by Mr White gave as a mean of ten readings 179.3 max 202 min 160 .

From these experiments it is demonstrated that it is inadvisable to have the coil extend the whole length of the magnet when a single ~~coil~~ is used. The difference between the deflection given by a flat coil and a coil extending over one half of the magnet is too slight to base any reasoning upon.

It is probable that the difference of effect will be brought out much better by

Conclusions
Coil should not extend from magnet. B

using finer wire and a very much greater number of turns.

Messrs Elliot Bros are now winding for me testing coils of the finest wire made for the purpose of settling this point.

It is conclusively settled that a very great advantage results from using fine wire in the coil. The difference between the deflections obtained in experiment 5 and that in experiment 3 is enormous although the size and general appearance of the coils were alike.

Fine wire
much better than
thick wire for
coils

The arrangements of these experiments will be understood from figures 1. 2. 2 3.

Monday Jan 28th 1878.

It seems to me that an apparatus can be constructed which when introduced into the circuit between the transmitting and receiving Telephones will have the effect of increasing the amplitude of the electrical undulations. A coil of wire of ordinary construction is found to act as a damper to the

Damping
effect of
helices in-
vestigated

Telephone more especially when a rod of soft iron is introduced within it. I

remember very well an experiment made a long time ago with Mr Watson in which we had about 4 empty helices of wire placed in the circuit.

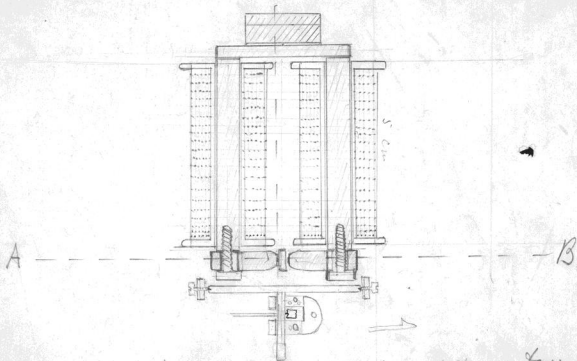
Mr Watson sang a continuous note into the distant Telephone and while I listened at the receiving Telephone I dropped rods of iron into the interior of the helices. As each rod was inserted a very perceptible diminution of loudness of sound upon the Telephone was observable.

We have also observed many times that it was difficult to communicate by word of mouth through even a short telegraphic line where a number of Morse instruments were in the circuit.

More resistance of the coils of the instrument seems immaterial to the telephonic current but the arrangement

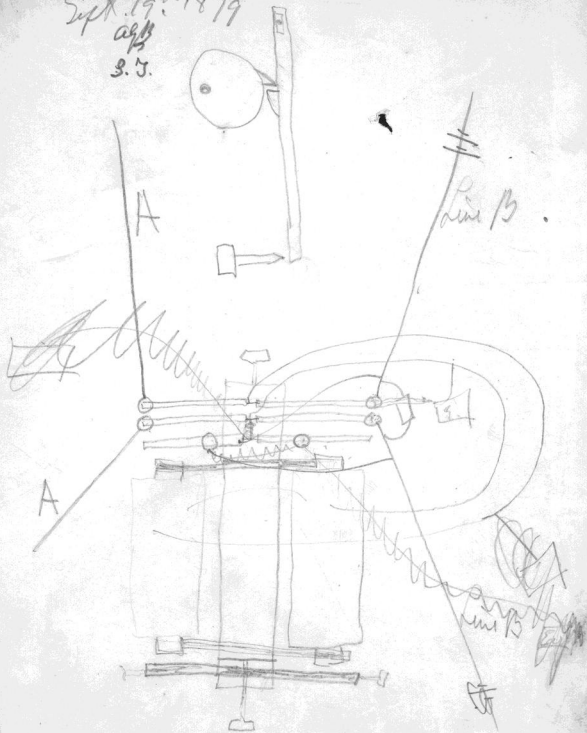
August 4th 1879

(Fig I)



Plan view of combined Bell, Commutator & Four-opener.
agg
16

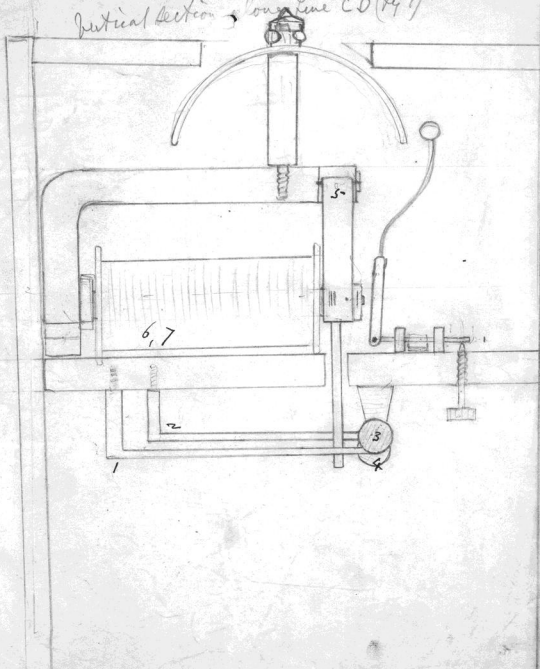
Sept. 19th 1879
a. j.
S. J.



August 4th 1879

Fig 3

Vertical Section, Long Line CD (Fig 1)



remember very well an experiment made a long time ago with Mr. Makon in which we had about seven empty helices of wire placed in the circuit.

Mr. Makon sang a continuous note into the distant Telephone and while I listened at the receiving Telephone I dropped rods of iron into the interior of the helices. As each rod was inserted a very perceptible diminution of the loudness of ^{the} sound ~~before~~ the Telephone was observable.

We have also observed many times that it ~~was~~ ^{is} difficult to communicate by word of mouth through even a short teleraphic line where a number of Morse instruments ~~are~~ ^{are} in the circuit. The mere resistance of the coils of the instrument seems immaterial to the telephonic current but the arrangement of the wire in a coil round a core of soft iron seems to weaken the sound from the Telephone in a wonderful degree.

I think I see clearly the explanation of this and therefore the way to remedy

Damping effect
of Helix
increased by
inserting soft
iron cores.

Effect of Helix
on the
wire.

Explanation

it

When a voltaic current is passed through a coil of ordinary construction a secondary current in the opposite direction to the primary current is generated in the coil. Thus at the moment of starting the current ^{it} is enfeebled. If the circuit is suddenly opened the secondary current induced by the cessation of the primary current ~~in the same direction as the primary current~~ ^{is} left unopposed and leaps across the break in the form of a spark

Induction of the current upon itself in coils of helix tends to decrease the amplitude of electrical undulations.

It is easy to understand then that the secondary current induced in a coil of ordinary construction opposes the primary current when (1st) the current is started (2nd) when the current is increasing in intensity

- Secondary induction opposes
1. commencement of current.
 2. increase of current.
 3. delays cessation of current.
 4. & delays cessation of current.

The secondary current is in the same direction as the primary current (1st) when the current stops (2nd) when the current is decreasing in intensity

A current constantly varying in intensity like the Telephone current is therefore constantly opposed by secondary induction. When the current is increasing

in intensity the secondary current tends to weaken it and when it is decreasing in intensity the secondary current tends to strengthen it

Thus the effect of a coil of ordinary construction upon the telephonic current is to decrease the amplitude of the electrical undulations and thus to lessen the sound produced.

But now suppose that instead of making a coil in the ordinary manner we wind a coil with two wires side by side and pass a current in one direction through the one wire and in the opposite direction through the other wire. We have then a primary current in opposite directions in contiguous wires so that the secondary currents induced on such a coil will strengthen the primary current (1st) when the current is started (2nd) when it is increasing in intensity and will lessen the primary current (1st) when the current ceases (2nd) when the current is decreasing in intensity.

Thus the effect of such an arrangement upon the Telephone

New arrangement
of coil.

Doubly wound
coil - so
arranged that
primary current
flows in opposite
directions through
contiguous wires.

Effect upon
Telephone
current is
to increase
the amplitude
of electrical
undulations.

current will be to increase the amplitude of the electrical undulations for when the current is increasing in intensity the secondary current serves to increase it still more and when it is decreasing in intensity the secondary current weakens it still more.

Thus the introduction into the circuit between the transmitting and receiving Telephones of a coil constructed as above described should occasion a marked increase in the loudness of the sounds produced ~~within~~ the Telephone.

A coil of such construction should be as transparent to telephonic currents of electricity as ordinary coils are opaque. To test this principle I took two pieces of wire each 15 $\frac{1}{2}$ ft in length. One of these pieces was formed into a coil of ordinary construction and arranged upon circuit with a galvanometer as shown in figure 11. The other piece of wire was cut into two pieces which were twisted together and the compound wire thus formed was

experiment
to test
theory.

made into a coil and arranged upon circuit with a galvanometer as shown in figure 5.

On the 2nd of January I made comparative experiments with these coils. The coil of ordinary construction was arranged as shown in figure 4 and a current of electricity was generated by dropping a piece of iron upon the pole N of the magnet N.S. from a height of 1 inch.

The mean of twenty observations gave a deflection of 40 degrees max 51 min 12

The double wire coil was then taken in place of the other and arranged as in figure 5. In this case the mean of twenty observations gave a deflection of 47.9 max 51 min 41

A telephonic circuit was arranged and Mrs Bell spoke into one Telephone while I listened at another. I introduced into the circuit while she was speaking the coil shown in figure 4 and then the coil shown in figure 5 but no difference was discernible in the loudness of the sound.

Two coils of equal length of wire. One of ordinary construction. Other doubly wound.

Double wire coil gave slightly greater deflection.

Doubly-wound coil did not sensibly increase the loudness of the voice.

produced from the Telephone

The results though supporting the theory above stated so far as they go are yet unsatisfactory and indecisive. I must have other coils made of finer wire and offering much greater resistance

Experiments
indecisive

Experiments were made last night on the effect of induction upon the Telephone

Induction

Two flat coils of wire were taken as shown at C. and D in figure 6. The coil C was arranged in circuit with the Telephone T and the coil D was in circuit with the battery B consisting of two Leclanché elements

Experiment
with flat
coils.
One in primary
circuit with
battery & key.
Other in a
separate circuit
with Telephone.

The coils C and D were first placed side by side and upon making and breaking the primary circuit by means of the key K a loud click was audible from the Telephone when the circuit was made or broken.

Operation
of key audible
to telephone
when coils
were 18 inches
apart.

Upon separating the coils C and D the sounds from the Telephone became more and more feeble but were still perfectly audible when C and D were 18 inches apart

A metallic disc interposed between the coils C and D seemed to exert no screening influence and when the coils C and D were placed one on each side of the head the inductive influence of one upon the other through the head was perfectly audible.

Metallic disk interposed did not visibly screen ~~the~~ induction.

(Curious, wasn't it.)

Last night I was much struck by an accidental observation. The Telephone 'T' was arranged as in figure 7. One terminal was held in the hand and the circuit was completed by touching the other terminal with the ^{myaltered} finger.

Both a passing current through body in circuit with Telephone. A sound was audible upon making circuit but none on breaking it.

A very perceptible sound was audible from the Telephone when the circuit was made but I could perceive nothing when the circuit was broken.

This seems a very extraordinary fact as under ordinary circumstances the sound produced by breaking a circuit is very much louder than that produced by making it.

I found the same effect was observed when the circuit was completed by dipping one

Same effect produced by water.

terminal into water as shown in figure 8. A sound proceeded from the Telephone when the circuit was made but no sound was audible when it was broken.

Induction

In place of the coil C figure 6 the coil shown in fig 4 was used. The arrangement is shown in fig 9. Upon making and breaking the primary circuit by means of the Key K very loud sounds were audible from the Telephone T. Utilising then the doubly wound coil shown in fig 5 making the arrangement shown in fig 10 the operation of the Key K produced no sound whatever upon the Telephone T showing that the current induced in one of the wires of the coil was neutralised ^{that in} by the other.

Doubly wound coil insensitive to induction.

The results of a few experiments made on Dec^r 30th 1894 are worth recording.

Motion of coil of permanent magnet in Telephone experiments

On sliding the coil C fig 11 which was in connection with the galvanometer G along the permanent magnet N. S. it was observed that the motion of the coil

from N to M produced a positive deflection from M to S a negative deflection from S to N positive and from N to S negative.

Upon moving a piece of soft iron towards the pole N a positive deflection was obtained at whatever point of the magnet the coil C was placed. A negative deflection was obtained by moving the soft iron away from the pole N .

Similarly the motion of a piece of soft iron towards the pole S produced a positive deflection and the motion from the pole S a negative deflection.

These effects were all reversed by reversing the magnet.

From these experiments it follows that the movement of ^{an armature or} ~~an~~ coil towards the centre of the magnet occasions

a current of electricity in one direction and ^{the} movement ^{produces a current of electricity} from the centre ^{of the magnet} in the opposite direction.

of the coil or armature

↑

Four equal coils A, B, C, D .

fig 12 were arranged upon circuit with the galvanometer G

Result.

Motion of coil or armature towards centre point of magnet occasions electricity of one kind by motion from the centre electric of opposite kind

First one coil A was placed upon the pole of the permanent magnet N.S. and the deflection produced by dropping a piece of iron upon the pole noted.

Multiple coils arranged in series.

The mean of 10 experiments gave a deflection of 75.6
max 82 min 68.

~~The~~ coils were then slipped on the magnet as in fig 13 and the deflection noted

Excessively greater deflection when four coils were ~~one~~ ^{two} than when one was employed.

The mean of 11 observations gave a deflection of 134.3
max 150 min 100

All four were however in circuit throughout experiment.

Three of the coils were then placed upon the magnet as in fig 14. The mean of 10 observations gave a deflection of 161.1 max 190 min 125

All four coils were then placed upon the magnet the deflection obtained as the mean of 10 observations was 237.4 max 290 min 150.

Particulars of the magnet.

Length of magnet $5\frac{7}{8}$ inches
diameter $\frac{1}{4}$ in.

The external diameter of each coil was $1\frac{1}{2}$ in the internal diameter $\frac{1}{2}$ in and the thickness $\frac{3}{8}$

Entered by me 28th Jan^y 1878. J.L.O.

AGK

Thursday 31st Jan^y 1878
Experiments made Jan^y 29th
A Rheotome having been
constructed for me by Mess^{rs}
Horne & Thornwaite I
employed it this evening
for the first time as a
means of studying induction.

The Rheotome was arranged
in circuit ~~in circuit~~ with
coil A and six cells of a
Leclanche battery as shown
in fig 15 and coil B was
connected in a separate
circuit with a Telephone.

The Rheotome was placed
in my lower Laboratory
and the coils A & B and
Telephone in my study so
as to be out of ear shot of
one another.

A very perceptible sound proceeded
from the coil A although
there was no iron core in
it. When coil B was
placed closely against coil A
sound proceeded from the
Telephone that was audible
all over my study.
Upon grad

brass discs. I could perceive no pulsating effect when a permanent magnet or a bar of iron was used in a similar manner

no pulsatory effect observed with straight magnet or bar of iron

Entered 1 Feb^y 1878 J. Lill

Feb. 4th 1878.

W. Lill

Experiments made Feb 2nd 1878
Experiments were made this morning to test a new idea concerning the neutralising effects of a solenoid.

Induction Continued

A Solenoid is affected by induction precisely as a wire is affected placed in its axis. It seemed to me from theoretical considerations that not only should a Solenoid be able to neutralise a current induced by outside sources in a wire forming its axis but should also be enabled to neutralise the currents induced on any wire contained within the Solenoid parallel to the axis.

Solenoid neutralizes currents induced in wire forming its axis when used as return wire.

Will Solenoid neutralize currents induced in wires inside it?

Will it do same for all wires inside it.

Fig 2nd represents a cross section of a Solenoid A and B is a wire forming its axis. If we suppose

the Solenoid to surround
 a cable of wires will not
 the influence of the Solenoid
 A be the same upon all
 the wires contained within
 that cable?

Will not
 Solenoid do
 as return wire
 for ~~all~~ a cable
 of wires contain-
 ing it?

Take the wire C for instance
 Although it is very much
 nearer A at the point D
 than the central wire is
 it is further away from the
 point E: so that the effect
 of the Solenoid upon the
 point C should be the
 same as upon the point
 B. Supposing then
 that we have a cable
 as in fig 28 within a
 Solenoid of wire some of
 the wires may be used for
 ordinary telegraphic purposes
 and other for telephonic
 purposes if the Solenoid
 is used as the return
 wire for the Telephone
 wire in place of the
 earth. For instance
 A.B.C may be ordinary
 telegraphic lines with batteries
 upon them and connected
 with the earth in the
 ordinary manner while
 D.E. may be used for
 telephonic purposes the Solenoid

Solenoid round
 cable of wires.
 May not
 some wires be
 used for telegraphic
 purposes & others
 for telephonic
 if telephone wire
 use solenoid
 as return wire.

F being used as the return wire.

The currents induced in the wires D E, by the operation of the telegraphic lines A B C should be neutralised by the currents induced in the Solenoid F. So that instead of having a separate return for each Telephonic circuit we may be able to use the wires as they at present exist by having a solenoid round the whole cable.

Experiments made this evening certainly prove that this is correct.

Experiment to prove theory.

A cable of 13 or 14 wires was made as shown in fig 29. An insulated wire A was twisted round the whole cable. A rheotome and battery was arranged in circuit with one of the wires. The Telephone was arranged in circuit first as shown at I with an external return wire. The pitch of the rheotome was emitted by the Telephone. The Solenoid A was then substituted for the wire W and the Telephone was

Cable of 13 or 14 wires. Wire twisted round whole cable.

~~One wire~~
Intermittent current passed through one of wires.

Sound audible when Telephone was connected with other wires using external return wire.

perfectly silent.

Each of the wires was
tried in a similar manner
and it was found that the
Solenoid when used as a
return wire neutralised
completely the currents induced
in all the wires of the cable.

Of course the importance
of this is manifest. For
if a Solenoid wire can
neutralise the inductive
influence of the wires upon
each other then a metal
pipe should do the same.

Hence it may be
possible that the ordinary
wires now used for
telegraphic purposes in London
may be used for telephonic
purposes by merely using
the metal pipe in which
the cable is laid as a
return wire.

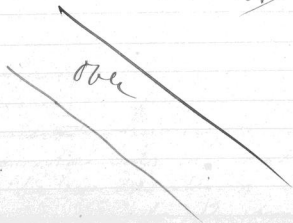
Telephone
perfectly
silent when
Solenoid was
used for
return wire.

Will not
metal pipe
do instead
of Solenoid

If so the
ordinary under-
ground wires
can be used
without change
by using the
pipe in which
they are laid
as return
wire.

Entered 14th Feb^{ry} 1878 J. W.

agf



Feb. 6th 1878

29

Experiment made 5th Feb 1878

Induction
continued

I obtained today a strip of brass foil 16 ft in length which was wrapped round a cable of wires shown in fig 29 so as to enclose it in a metal pipe marked A in fig 30. The foil was not enough however to cover the whole of the cable which was found to be 28 ft in length.

Cable of wires wrapped round with metal foil.

Foil not long enough to cover the whole length.

One of the wires of the cable was connected with a Telephone wire leading to my cousin's house half a mile away and Dr Bell operated in his house with the key K. A Telephone was arranged in circuit with another wire in the cable and the sound of the operating was clearly audible.

When foil-
pipe was
used as
return wire,
sound ~~for~~
decreased
but not
silenced.

When the Telephone was arranged so as to use the metal pipe as a return wire as shown in fig 30 the sound of the operating was materially decreased. This seems to favour the supposition that a metal pipe containing a cable may be used as a return wire for purposes

of neutralising currents induced in the wires of the contained cable.

It may be however that some ratio must be established between the resistance of the portion of the direct wire and the portion of the return wire under inductive influence.

The metal pipe A must evidently offer very much less resistance than the wire contained within it so that the metal pipe A forms a very much smaller portion of the whole circuit than the enclosed wire does.

It would be a strange circumstance if a current induced in a conductor forming only one hundredth of the whole circuit should be able to neutralise a current induced in a conductor constituting one half of the entire circuit.

It may be however that the surface of the conductor exposed to inductive influence in the case of the pipe A is so much greater than the surface of the contained wire that the currents

Perhaps ratio must be established between resistance of direct & return wires under inductive influence.

Pipe offers slight resistance compared to wire inside.

Strange if current in wire $\frac{1}{100}$ of circuit could neutralise current induced in $\frac{1}{2}$ circuit.

May be however that surface of conductor pipe exposed to inductive influence is so much greater than surface of contained wire that one may balance the other.

induced in the one may be neutralised completely those induced in the other.

There is a problem here for thought.

Take two parallel wires of equal lengths but very different ^{thicknesses} ~~cross sections~~. Place them at equal distances from a wire through which an interrupted current is passed and see whether the current induced in the thin wire will neutralise completely that induced in the other wire. Also coil one of the wires round the other and note the effect.

Is a Solenoid of thin insulated wire affected in the same manner as a straight wire the diameter of which is the diameter of the Solenoid and the resistance the resistance of the Solenoid?

I met Dr Bell at University College this morning and he introduced me to Mr Page Demonstrator in the Physiological Laboratory who showed me some new experiments with the Telephone. He showed me that a galvanoscope frog is exquisitely

~~Two wires~~
~~of different~~
~~thicknesses~~

Best case
Case
current induced
in thick wire
neutralises current
induced in thin
wire of equal
length.

Is solenoid
affected as a
straight wire
whose diameter
is the diameter
of solenoid &
resistance the
same as solenoid?

Experiments
made by
Mr. Page
Demonstrator
in Physiological
Laboratory
University College.

sensitive to the current produced
by the Telephone and he also
proved to my satisfaction
that ~~Lippmann's~~ ^{Electrometer} Capillary
~~Galvanometer~~ can be used
as a means of measuring
the intensity of the currents
produced by the Telephone
Entered 6th Feb^y 1878 J.L.W.

Galvanoscope
not - capillary
sensitive to telephone
current.

Lippmann's
Capillary Electro-
meter - can be
used as a means
of measuring
Intensity of
Telephone current.

(Feb. 7th 1878)

AGB

Experiments made Feb^y 6th 1878

Induction
continued.

A lead pipe 28 feet in length shown
at H fig 31 was experimented upon
this evening. A cable of six
insulated wires was laid inside

Cable in
lead pipe
28 ft. long.

One of the wires was connected with
battery and rheotome and a Telephone
It was arranged alternately in circuit
with the other wires using the lead
pipe as a return wire.

When the external wire W shown
in dotted lines was used as a
return wire the sound of the rheotome
was loudly audible in the Telephone
T but when the lead pipe was
used the sound of the Rheotome though
still audible was very faint.

lead pipe as
return wire.

Lead
sound faintly
audible.

Resistance introduced into the
circuit at R rendered the sound
of the Rheotome completely inaudible
when two thousands Ohms had been
inserted. The sound was barely
audible when one thousand Ohms

Artificial
resistance
reduced sound
still further.
Silver with
2000 Ohms.

was inserted and completely disappeared as the two thousand was reached.

Upon reflecting upon the experiments made by Mr Page with Leppmann's Capillary Electrometer I see that the principle of the action of the Electrometer can be applied in numerous ways to the Telephone.

The principle of the action as I apprehend it is this: —

The mercury moves much more freely towards the open end of the tube than in the other direction hence suppose the mercury to receive a large number of impulses of equal strength but alternately in one direction and ~~on~~ the other it is evident that the motion produced by the impulses towards the open end of the tube will be very much greater than the motion in the other direction. In fact it reminds me of the old problem about the snail crawling up a wall. For every two feet that the snail crawled up it fell back one foot and a half. It is evident however that this would be ^{equivalent to} a continuous advance of 6 inches.

In a similar manner the 6 to 8 fro motion of the mercury in the capillary tube should lead to a continuous advance of the mercury in the tube. If

~~Mr Page's experiment with capillary Electro-meter. repeated for the purpose of a new~~

Explanation of action of Capillary Electro-meter.

Mercury moves towards open end of pipe more freely than in opposite direction.

To & fro motion of mercury in capillary tube. Resultant continuous advance of mercury up tube.

this is so the mercury in a capillary tube should rise under the influence of a sound and an apparatus can be constructed to take the place of the vibratory circuit breaker in multiple telegraphy, upon the principle shown in a note ~~Nov~~ written Nov 6 1877 page 55 of my old note book, and to operate a call bell for the Telephone independently of a battery upon the main circuit.

Same effect
should follow
from mechanical
vibration of
mercury by
a sound.

Can be used
for vibratory-
circuit breaker
& call bell
for Telephone.
as suggested
in old note-
book Nov. 6th.
1877 page 55.

In fact after seeing the action of the capillary Electrometer I am so convinced that my old idea of an Electric Phonometer is correct that I shall here record on a permanent form the notes made upon this subject on Oct 27th and Nov 6th 1877 extracted from my old note book page 50 and page 55.

I find a note in Ganot's Physics bearing very closely upon this subject. Ganot's comp paragraph 283

See Ganot's
Physics par. 283

"Guthrie finds that when one prong of a tuning fork is enclosed in a tube provided with a capillary tube dipping into a liquid and is set in vibration by bowing the free prong the air around the enclosed prong is expanded and he thence concludes that the approach above described of a suspended body to the sounding fork is due

Liquid in
capillary tube
rises - when
vibrating prong
of tuning fork
is inserted in tube
leading to it.

to the diminution of the pressure of the air between the fork and the body below that on the other side of the body."

I shall try the following experiment at once.

In the mouth piece of a Telephone fig 32 I shall insert a bent pipe with a capillary prolongation shown at H. Mercury will be inserted in this pipe. One terminal of a battery will come from B through the wooden mouth piece dipping into the mercury and the other terminal C of a battery will go down the capillary tube so as to be close to the mercury A but not touching it.

Upon singing to the plate D I expect that the mercury in A will rise and make contact with the wire C so as to ring an alarm bell or operate telegraphic apparatus. If this is the case the plate D can be set in vibration by the varying contractions of a magnet and an arrangement like this placed at the receiving end of a circuit can be operated by the voice alone.

For instance let the arrangement shown in fig 32 be attached to a receiving Telephone. I want to attract the attention of a person

Try, ~~capillary~~ tube
Capillary tube
connected with
telephone plate.
will mercury
rise & make
local circuit in
telephone
plate vibrates.

Stationed there, I take my Telephone and merely sing a continuous note. The mercury in the capillary tube at the receiving end rises making contact with the wire C ring a bell and the attention is drawn.

Another form of this apparatus for purposes of multiple telegraphy is shown in fig 33. The mercury in the capillary tube H will only rise when the reed B is thrown into vibration. A number of similar instruments can be arranged at different pitches each reed operating a capillary tube as shown.

Application
to Multiple
Telegraphy in
place of
Vibratory
Circuit-
breaker.

Extract from old Note Book
dated Oct 2nd 1877.

"About Oct 16 a thought occurred to me that has been haunting me since:—How to obtain a motor power from sound. It struck me that for many purposes the vibratory circuit breaker would be unsatisfactory and uncertain and that multiple telegraphy to be a success should have some more certain means of causing the audible signals to record themselves automatically on the work apparatus mechanically.

Extract from
old note book
bearing upon
subject.

We know that liquids to expand

under the influence of heat and we explain the process by supposing that the molecules are thrown into vibration and thus strike the neighbouring molecules and the body as a whole expands. If this is true why should not fluids expand in a similar manner under the influence of a sound.

Experiment to try. Will liquid rise in tube ^(fig 34) H when water in vessel B is agitated by a sound as for instance when tuning fork is presented to it. If so the water in tube C (fig 35) could be made to push a piston and open or close a local circuit when the Telephone D produces a sound.

It seems to me that the fluid would certainly rise in pipe C if a more sluggish fluid were employed than water e.g. glycerine or even oil. I should think glycerine would be the thing for it could be diluted with water until the requisite degree of sensibility is obtained.

It is probable that every cavity filled with fluid has a key note of its own to which the liquid will respond in which case a series of bottles could be arranged as follows (see fig 36) so that the

liquid on each bottle would rise when a certain note is struck and no other.

Perhaps the expansion would be more marked in an elastic fluid. Try following experiment ^{see fig 37}
Telephone A (fig) air chamber
B bent pipe C - Will fluid in pipe C rise when sound is transmitted.

Try also an early sound as in D (see fig 38)

Nov 6th 1897. Expansion of fluids by sound continued.

If fluid expands under vibratory action of sound then the expansion should theoretically be proportional to the rapidity of the vibration.

Hence a thermometer could be simply converted into a phonometer.

If the amplitude is uniform the liquid should rise with increased height of pitch. If pitch is uniform with increased amplitude.

If for no other purpose liquid appliances to Telephone could be made to operate a bell &c and attract attention. For instance with the large Telephones Mahel can feel the diaphragm move when the diaphragm at the other end is tapped by a pencil. Now if diaphragm formed one

side of a receptacle filled with fluid and a narrow piped out of the receptacle as in diagram (see figs 39 & 40) then when distant telephone is tapped liquid would rise to considerable height in pipe and could release mechanism or make electrical contact and ring a bell. Perhaps too the amplitude of vibration of liquid in pipe might be greater than diaphragm and the sound of speaking be more audible from pipe than from membrane. Worth trying. This may be the action of present apparatus in which case the sounds would be louder when an incompressible fluid is employed.

Upon consideration it seems to me that liquid can be made to rise in pipe ^(see fig 41) to a different height when it is agitated by a sound by retarding the motion of fluid so as to render its action more sluggish than that of the sound vibration. In which case the principle of the action is the same as vibratory contact breaker.

This can be accomplished (1) by using viscid fluid and (2) by reducing the diameter of the pipe B so that the friction of the

of the fluid against the sides of the pipe may retard its motion.

Take latter case. When magnet is weakened diaphragm A (see fig 42) is released and as liquid is incompressible a considerable amount of (say) water is forced up pipe B. Now magnet is strengthened A comes towards magnet but the friction of pipe B delays descent of water and it has not time to run all back before it is again forced up. In this case the vibration of A would give a steady push to a piston in B and operate mechanism as in vibratory circuit breaker. Similar effect would be produced in viscid fluid without friction pipe.

Probably it will only be viscid fluid that will expand as whole under influence of sound.

Adaptation of principle to multiple telegraphy.

When metal pipe A (see fig 43) is above B local circuit is made when reed vibrates and by putting metal pipe below B circuit would be broken.

Great defect of vibratory circuit breaker is that it is not opened until reed has attained considerable amplitude. Fluid

arrangement would act at once.

If ~~when~~ Telephone plate acts upon fluid height of ~~liquid~~ is proportional to either pitch or loudness of sound. ^{an} ~~an~~ entirely new field is opened up for telegraphing - indeed I can conceive it possible that almost any mechanical work can be accomplished or directed at a distance.

Suppose height of liquid to be proportionate to pitch of sound then following results: piston A (see fig 44) which changes pitch of organ pipe when moved will cause corresponding motion of piston B actuated by expansion of fluid C.

If height of liquid varies with amplitude then make arrangement like this at receiving end (see fig 45). Pistons worked at right angles to one another could control the position of a material point (say a pencil) and cause it to move into any desired spot upon a plane surface and thus to trace any outline upon that surface. Or they might be arranged so as to cause pointers to indicate upon a map the exact locality of any distant

object the direction of which is observed by two separate observers

Let observers at A and B (see fig 46) desire to telegraph to a distant station D the exact place at any moment of the ship or object C. Have automatic telescope at each point and each observer merely keeps the object in view then as angle C.A.B. varies automatic attachment changes the loudness of musical tone At receiving end D reads ^{fig 47} turned to pitches operate long rods on map A.C B.C and the intersection of the rods shows the place of the ship upon the map

Setth of the 1877

Experience has shown that mercury is not well adapted for making and breaking a voltaic circuit on account of its liability to oxidation and so forth. If the mercury or liquid could be used to raise a piston and either mechanically make or break a local circuit or release mechanism it would be better. Still better however if the effect could be produced without the employment of any

liquid at all

— can well remember an experiment very familiar to schoolboys and one that has in times past caused me considerable annoyance namely the placing in the sleeve of an ear of barley with the beard downwards. Every motion of the arm causes the barley to move up the sleeve and the more you shake your arm the farther does the barley work its way upwards.

Attach to the diaphragm^{of} a Telephone ^{as fig 48} a metal rod **B** a wire which passes freely through the interior of a metal pipe **C** and place inside this pipe a delicate metallic spring **D** shaped like the letter **V** upside down. Will not the longitudinal vibrations of the central rod or wire cause the **V** shaped spring to ascend the pipe in a similar manner to the ascension of the ear of barley up the sleeve. If so one portion of the pipe and the wire could be insulated ^{as at F & G} and the **V** shaped spring could be made to ~~effect~~ ^{effort} a voltaic current when it has

Enclosed Memorandum is that referred to
on page 44 of Experimental Book under
date 13 Sept 1898. J. L. W.

July 3^d 1877

The success of the hollow magnet telephone shown in Fig 1. which was made last week has today suggested further modifications shown in Figs 2, 3, 4, 5, & 6.

Fig 1



- A. Hollow magnet as speaking tube
- B. Coil
- C. Plate or disk
- D. Wooden support for plate

Fig 2



Fig 3



Fig 4



In Fig 3 & subsequent figures the magnet being hollow serves the purpose of magnet, mouthpiece handle and holder for the plate and in addition the plate by being attached to one rim of the magnet becomes itself ~~one~~ is polarized.

Fig 5



Fig 6



The advantage of Fig 4 is that the plate C can be pushed away with the finger if it sticks to the pole of the magnet - but indeed the air itself acting from the same side as the magnet tends to prevent the plate from adhering.

The only disadvantage that I can see in these forms of apparatus lies in the fact that the membrane is exposed. With a thick plate however this would be a matter of minor consideration.

For other forms see over the page -

Over

The following forms are for large and stiff plates as in the large box telephones.

Fig 7



Enough call could be obtained with other apparatus.

Fig 8



If these large ones were made to stand on a sounding box - it is probable that a loud- without the necessity of

Fig 9

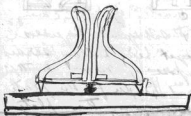
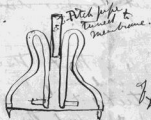


Fig 10



A good call might be made in this way. Let the membranes all be of a certain pitch and have a pipe of similar pitch as plug for mouth piece as in Fig 11.



These devices - with the exception of that shown in Fig 1 - remain to me this evening - Tuesday July 31

Alexander Graham Bell

This is the paper referred to on page 44 of experimental book under date Feb 4 13th 1878

J. L. Warner

passed the insulated portion F.G.
 Perhaps a circular metallic
 collar like the leather collar
 used in Bramah's Hydraulic
 Press may do. (see Ganot's
 Physics fig 73)

All the foregoing from the
 twelfth line of page 34 was
 entered by me today at I.W.
 Feb 4th 1878 J.W.

[Signature]

Feb 13th 1878

Mr Bell has today discovered
 the memorandum marked stated
 July 3rd 1878 among some old
 papers and as he thinks it may
 be of importance as bearing upon
 his new patent for Tubular Magnet
 Telephones he requests me to preserve
 it here in an unopened envelope

J.W.

[Signature]

16 Feb 1878

The idea shown in fig 48 shows clearly
 the principle to be worked out in causing
 sounds automatically to record themselves

I have a body of some kind that will
 move more easily in one direction than
 than the other when such a body is
 caused to vibrate by the action of a
 sound it must go continuously onwards
 in the direction in which it is freest

to move

Why should not a valve be just the thing desired. For instance let A in fig 149 be the plate of a Telephone. B a pipe the two extremities of which are closed by valves C.D. opening in opposite directions. When the plate A is moved upwards the valve D opens and C closes and air passes into the pipe B in the direction of the arrow head. When the plate A is moved downwards the valve C opens and D closes so that air escapes from the pipe B in the direction of the arrow head. If then the plate A is caused to vibrate the valves C and D open alternately and a continuous current passes through the pipe B which current may be utilised to move a piston or other movable part and open or close a local circuit or release mechanism.

It may be that the inertia of the valves C and D may prevent them from opening and closing with sufficient rapidity under the influence of a sound. In this case it is only necessary to substitute for the valves C and D beating reeds tuned to the same pitch. The one reed C opening downwards and the other reed D upwards. Under these circumstances a current of air would be produced in the pipe only when the plate A emitted the musical

tone of the reeds C and D

This arrangement can evidently be used in place of vibratory circuit breaker for the purpose of multiple telegraphy.

It is only necessary to have a number of pipes like B communicating with the same air chamber the ends of which are closed by beating reeds of various pitches.

The above was noted in the old note book on last Saturday Feb 9th

Entered Feb^y 16th 1878 J. L. W.

Alf

18 Feb^y 1878

Experiments made Feb^y 16th

I recommenced experiments this evening with Sir William Thomson's reflecting Galvanometer

I repeated experiment shown in fig 3 and I found that much more accurate observations could be made by plunging the armature away from the pole of the magnet than by allowing it to drop from height

For instance compare low readings on Jan^y 2nd Experiment 5 results of which are noted on page 44 with those obtained tonight see over

Jan^y 2 Mean of 10 readings 179.3 max 202 min 160

Variation 42 degrees

Feb^y 16th

mean 220.1 max 222 min 219

Variation 3 degrees

Mean of readings max. min. variation

Jan 2	Ditching Armature	179°.3	202°.0	160°.0	42°
Feb 16 th	(1) Blucking Armat. away	220°.1	222°.0	219°.0	3°
	(2) " " " "	175°.0	180°.0	170°.0	10°
	(3) " " " "	^{and of readings} 222°.0	222°.0	222°.0	0°

I shall repeat the experiment shown in figs 1. 2. 3 with the exception that the deflection produced by pulling armature away is to be taken instead of deflection produced by letting the armature drop.

I tried tonight the effect of removing suddenly armatures of different sizes from the magnet and the results obtained were unexpected and important. Perhaps it is too rash to generalize from the few observations made so far but it really seems as if the strength of the current produced by the plate depends more upon the surface of the plate than upon its mass.

Exp 1 A bright steel plate 4 fig 50 3 inches in diameter was placed upon the pole N of a Magnet which was connected with the Galvanometer G. When the needle had come to rest the plate was suddenly removed and the deflections obtained are shown below

Exp. 2 A ferrotype plate 3 inches in diameter was next used in place of the steel plate. The results are shown below

Exp. 3. A ferrotype plate of similar thickness to the last but only $2\frac{1}{4}$ inches in diameter was then used with the results shown below

Exp. 4. An iron tack was laid upon the pole of the magnet as shown at A fig 51. For the results see lower down. The ferrotype plates were then used singly and together

Exp. 5 The large ferrotype plate 3 inches in diameter gave the deflections shown below

Exp. 6 The small ferrotype plate was then used alone with the result shown below

Exp. 7 Both plates were then placed upon the pole, ^{the small plate being above} and both were removed simultaneously. The results are noted below

The two ferrotype plates were then laid upon the pole of the magnet as shown in fig 52 and the deflection obtained by removing the upper one was noted. The results are below.

See over

Start	First	P. No.		Lth			
Exp 1.	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8
140	220	202	40	220	208	222	30
145	220	207	40	222	207	222	31
180	219	207	40	221	205	222	30
148	220	202	40	221	204	222	30
146	220	205	40	220	205	222	28
146	220	202					
144	220	204					
142	222	201					
178	220	205					
178	220	201					
Means	175	220.1	203.6	40	220.8	205.8	222

Centered the 18th Feb^{ry} 14 2.00.

Agk

19 Feb^{ry} 1878

Experiments made Feb^{ry} 18th

I cut 4 square plates of ferrotype
thin evening of different sizes & experimented
in the way shown in fig 50

Exp. 1.

A plate of iron 1 sq cm in area

Exp. 2

A plate of iron 4 sq cm in area

Exp 3

A plate of iron 9 sq cm in area

Exp 4

A plate of iron 25 sq cm in area

For results see below.

over

Exp. 1	Exp. 2	Exp. 3	Exp. 4
35	94	152	216
36	95	150	223
36	100	154	220
30	101	154	223
36	92	150	220

Means 34.6 95.8 152 220.4

The iron was similar in all these plates and the thickness was the same but of course their weight varied with the area.

A magnet was employed 6 inches in length the diameter of the pole of the magnet 6 mm. The diameter of the coil employed was 5 cm. thickness 6 mm.

Centered the 19th Feb^{ry} 1878. J. D. D.

all

Feb^{ry} 21st 1876

Experiments made Feb^{ry} 19th

This evening experiments of a similar nature to those made last night were undertaken. A piece of sheet iron was taken very much thicker than the ferrotype used yesterday. I have no means of ascertaining its exact thickness but I should guess it to be about 1/20 of an inch.

Eight squares were cut out the sides of which measured 1. 2. 3. 4. 5. 6. 7. and 8 cm. so that the surfaces were as the squares of these numbers. A plate whose side measured 5 cm.

First Experiment

Ferriotype 5 cm. plate	210	Thick Iron 5 cm. plate	222
" " "	230	" " "	230
" " "	230	" " "	230
" " "	233	" " "	235
" " "	230	" " "	233
Means	<u>224.6</u>		<u>230</u>

Second Experiment

Thick Iron cut in squares the sides of which measured —

1 cm.	2 cm.	3 cm.	4 cm.	5 cm.	6 cm.	7 cm.	8 cm.	6 cm.	8 cm.	5 cm.
140	102	160	200	235	252	263	212	252	254	253
140	90	160	198	239	249	251	252	254	253	222
38	110	102	200	232	250	262	202	253	222	252
140	105	140	261	232	250	265	215	252	262	252
143	100	152	260	232	252	262	212	254	232	260
Means	110.2	102.4	152.8	199.8	234.0	250.6	253.6	218.6	253.0	242.6

was compared with a ferriotype plate of similar shape & size. The deflections obtained are shown under the head of the 1st Exp.

Squares of iron were then compared one with another and the results are shown under the head of the 2^d Exp.

It will be seen that the plate 7 cm. sq. gave the maximum deflection and that there was a marked fall when the plate 8 cm. sq. was used. Three separate exps. were made with the 8 cm. plate in order to be sure that the fall in the deflection was not due to some accidental circumstance in the

reading. I did not observe any difference in the appearance of the 8 cm. plate and the other except that the plate is slightly rusty at one point. All of the plate shown were cut from the same piece of sheet iron so it is hardly likely that there is any difference in the material.

The experiments seem to agree with those made last night in showing that surface has more influence upon the current produced on the Telephone than mass.

Experiments made 20 Feb 1898

In order to determine decisively whether the mass of the armature produced any effect three pieces of iron were taken of enormously different sizes but presenting the same surface to the magnet. They are shown in fig 53. A is a thin piece of ferrotype iron 9 mm in diameter B is a soft iron pole piece of similar diameter the dimensions of which are diam. 9 mm. depth 9 mm. & depth of the screw 6 mm. C is a rod of soft iron diam. 9 mm. length 64.5 mm. The deflections obtained are shown at exp. 1. 2 and 3 lower down [1 ferrotype iron - 2 soft pole piece - 3 iron rod] The iron rod C was then laid sideways on the pole of the magnet as in fig 54 and the deflection taken upon removal

The results are shown at Exp. 4

The keeper of a powerful compound magnet shown at A fig 55 was then taken and a piece of thin ferrotype iron was cut of the same size as the smooth surface of the keeper which is shown at B fig 55. The measurements of the surface were ^{breadth} ~~length~~ 17.5 mm. length 45 mm.

The deflections obtained when the ferrotype iron was employed are shown under head of Exp. 5 and those obtained with the keeper under head of Exp. 6. This experiment conclusively proves that the mass of iron does have a very great effect.

A piece of ferrotype iron shown in fig 56 was next taken and the deflection observed. It was then doubled so as to present double the thickness but only one half the surface. It was then folded a third time & the deflection observed & again ^{fourth} ~~third~~ time.

The results obtained are shown under the head of Exps. 7, 8, 9 and 10.

The surfaces exposed to the magnet were in the proportion of $1 : \frac{1}{2} : \frac{1}{4} : \frac{1}{8}$ and the thicknesses were in the proportion of the numbers 1, 2, 4, 8.

The experiments shown in figs 1, 2, 3 ^[see diagram page 3] were then repeated with coil of high resistance & by removing armature instead of allowing it

to drop upon the pole. Three coils were taken shown in fig 57. A, B and C particulars of which were as follows

	Coil A	Coil B	Coil C
Length	0.6 cm	8.6 cm	15.2 cm
Ext. Diam	5.0 "	1.8 "	1.7 "
Int. Diam.	0.95 "	0.95 "	0.95 "
Length of wire	238 yds	238 yds	238 yds
N ^o of convolutions	2423	5750	6085
Temp. under which resistance			
resistances were measured	16°	16°	15°
Resistances	280 ^Ω	285 ^Ω	249 ^Ω
Conductivity	94.8	94.8	94.8

Particulars of Magnet

Length 14.4 ^{cm} ~~mm~~ Diameter .6 mm.

The coils were arranged upon the magnet as shown in fig 58 at A, B, & C and the deflection obtained by removing the square plate of ferrotype from the side of which measured 5 cm. are noted under the Head of Expts 11. 12. 13

See over.

Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Exp. 8	Exp. 9	Exp. 10	Exp. 11	Exp. 12	Exp. 13
25	102	222	210	152	230	240	202	162	138	222	202	110
21	102	222	195	150	228	240	202	165	138	220	202	110
21	102	232	185	152	232	240	202	167	138	222	202	110
20	102	212	193	152	238	241	202	165	138	222	201	110
23	102	212	190	153	235	238	202	166	138	223	198	112
22.0	102.0	220.0	194.6	157.8	232.6	239.8	202.0	164.8	138.0	221.8	201.0	110.4

All the foregoing from the twentieth
line of Page 80 entered by me
this 21st Feb^{ry} 1898 J. L. W.

25th Feb^{ry} 1898

Experiments made Feb 24th.

The comparatively slight deflection
obtained by using the 8 cm. plate of
iron as shown on page 57 led me to
think that there must be some
peculiarity about the plate itself and I
therefore determined to cut the plate
down and see whether I got an
increase by diminishing the surface.

Before doing this however I determined
to make a comparison between the 7 cm.
plate and the 8 cm. and see whether
the effects were similar to those noted
page 57. The results are as follows.

7 cm. plate. 230. 221. 230. 235. 225. Mean 228. 2.

8 " " 208. 230. 212. 232. 220. - " - 220. 4

The great variation in the readings seems
to be caused by impatience on my
part. It is difficult to wait until the
needle has come entirely to rest. If

The needle is swinging in the proper direction when the plate is pulled off the reading is increased and if on the other direction it is diminished.

I made another comparison allowing the needle much time to come to rest and then pulled the plate off as forcibly and suddenly as possible. The results were

7 cm. plate 238. 249. 242. 238. 247 Mean 242.8

8 cm. plate 205. 215. 210. 225. 238 — " — 218.6

In order to guard as much as possible against the influence of the swinging of the needle upon the result I have determined to watch the direction in which the needle is swinging allow it to come to rest as nearly as possible take the readings and then withdraw the plate while the needle is swinging towards the right for one reading and while it is swinging towards the left for the next reading.

This method of alternate swingings will probably ~~will~~ give a more correct mean.

Taking the 8 cm. plate for the purpose of cutting it down I thought I would make a careful reading and I balanced the plate very carefully upon the pole of the magnet as in fig. 59.

I was surprised to obtain a very much greater deflection than before. It then struck me that the 8 cm. plate was not perfectly flat and that formerly

The maximum number upon the scale is 365.

I attempted to repeat experiments shown on page 51 using a thicker and larger magnet than before. The former magnet was 14.4 cm. in length and 6 mm in diameter. The other magnet was 15.25 cm. in length and 9 mm in diam.

Commencing with the 3 cm plate the deflection obtained with the smaller magnet was 152.8 (see page 51) that obtained with the longer magnet 272.

With the 4 cm. plate small magnet 199.8

Large Magnet 365.2

5 cm plate small magnet 234

Large magnet - far off the scale

The particulars with the large magnet are shown under head of Exps. 10. 11. 12. ~~13.~~

Exp 10. 3 cm plate 275. 275. 268. 282 260 Mean 272.0

- " 11 4 - " - 370 370 359 362 365 365.2

- " 12 5 " " far off the scale

Centered. the 25 Feb¹ 1898 4215

26th Feb¹ 1898

Experiments made Feb¹ 25th

I have yet made no experiments to test the effect of resistance upon the Telephone current so today I took a ferrotype plate 5 cm. square and a thick iron plate 5 cm square and tested their deflection through resistance

Unfortunately I do not know the resistance of the Galvanometer so that the results are not so valuable as they might otherwise be. I have written however to Mr Le Nez Foster and hope that he may be able to send me some particulars of the Galvanometer.

Size of Plate. 5 cm.

[illegible]

I have obtained a delicate balance and have weighed very carefully the iron and ferrotype plate employed in previous experiments and the weights are given ~~below~~ ^{below}

	size 1 cm	2 cm	3 cm	4 cm	5 cm	6 cm	7 cm	
Weight Ferrotype	2.5	8.0	17.5		57.3			grs
- " - Thick Iron	7.5	29.5	69.5	116.0	186.4	263.0	359.0	- "

Centered the 26 Feb^{ry} 1878 J. L. L.

24th Feb^{ry} 1878

Experiments made 26 Feb^{ry} -

Experiments made to test the influence ^{of position} of the coil - A magnet was employed the length of which was 15.25 cm. diam 0.9 cm. The coil employed is that described as coil A on page 54. It was first placed flush with the top of the magnet and deflection taken upon removing plate of thick iron 5 cm square used in the former experiments.

The coil was successively moved lower & lower down the magnet and the deflections taken. The position of the coil is noted by noting the distance between the top of the coil and the top of the magnet.

Finding that the deflection obtained sent the spot of light off the screen when the coil was near the end of the magnet a resistance of 400 Ohms was included in the circuit and the scale was

Deflection	Equiv ^t in cm.	Deflection	Equiv ^t in cm.
354	10.62	84.2	2.52
376.2	11.286	560.4	1.81
360	10.80	641.2	1.23
340.8	10.22	721.4	.94
323	9.69	822.4	.67
313	9.39	916.2	.48
301.4	9.04	1010.6	.31
1 287.8	8.63	1158.6	.25
273.2	8.19	1216.8	.20
2 190.8	5.72	1313.6	.10
3 129.4	3.88	1413.0	.09
		1492.0	.06

Deflection	Rel. ^{to} Value	Deflection	Rel. ^{to} Value
10.62	.9407	2.52	.2232
11.286	1.0000	1.81	.1683
10.80	.9569	1.23	.1089
10.22	.9055	.94	.0832
9.69	.8585	.67	.0593
9.39	.8320	.48	.0425
9.04	.8009	.31	.0274
8.63	.7646	.25	.0221
8.19	.7256	.20	.0177
5.72	.5068	.10	.0088
3.88	.3487	.09	.0079
		.06	.0053

Pos. ⁿ (top) of coil	Rel. ⁿ to whole Mag. ^t	Pos. ⁿ (top) of coil	Rel. ⁿ to whole Mag. ^t
1 cm.	.0065	47 cm	.3082
2	.0131	57	.3738
3	.0197	67	.4393
4	.0262	77	.5049
5	.0328	87	.5705
6	.0393	97	.6361
7	.0459	108.5	.7115
8	.0525	118	.7738
17	.1115	128	.8393
27	.1770	138	.9049
37	.2426	146	.9573

Pos. ⁿ (middle) of coil	Rel. ⁿ to whole Mag. ^t	Pos. ⁿ (middle) of coil	Rel. ⁿ to whole Mag. ^t
3 cm.	.0197	40 cm	.2623
4	.0262	50	.3374
5	.0328	60	.3935
6	.0393	70	.4590
7	.0459	80	.5246
8	.0525	90	.5902
9	.0590	100	.6558
10	.0656	111.5	.7212
11	.0722	121	.7935
20	.1312	131	.8590
30	.1967	141	.9246
		149	.9770

April 10th 1898

Experiments made April 9th

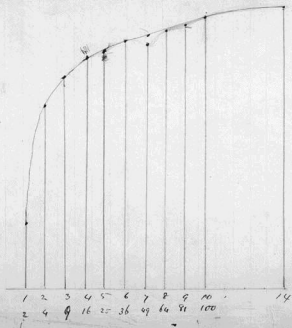
The experiments noted on page 61 seem to indicate that the current produced on the Telephone when the top of the coil is about 1 m.m. from the top of the magnet is greater than when it is flush with the magnet.

It has struck me however that the deflections noted on page 61 when the top of the coil was flush with the top of the magnet are misleading for the plate under the circumstances could not have made full contact with the top of the magnet. The experiments numbered 1. 2. 3. 4 on page 57 show what enormous differences result from variations in the amount of surface in contact with the plate.

In order to test whether the slight deflection shown on the first experiment on page 61 was due to the coil being flush with the top of the magnet or to a partial contact between the plate and the magnet the experiment was repeated this evening. A piece of soft iron A fig 62 being used instead of the plate formerly employed. The dimensions of this armature were length 9.8 cm. breadth 0.9 cm.

The deflections were observed with the coil at different portions of the magnet as in former experiment.

The coil used was that described as



Thursday Apr. 9, 1878.

Magnet 15.3 centi. lgt.
0.9 " dia.

Coil, flat used in
former experiments.

Soft iron armature,
9.8 centi. lgt.
0.9 " dia.

First experiment.

Top of coil 9.8 centi
from top of magnet.

Deflection ~~22~~

$$22 - 22 - 21 - 21 - 20 = 21 \frac{1}{5}$$

106
21.2

21.2

Second experiment.

Top of coil 6 centi.

Deflection,

$$+ 58 - 59 - 59 - 58 - 59 = 58 \frac{3}{5}$$

58.6

Third experiment.

Top of coil 4.3 cent.

Deflection,

$$102 - 102 - 100 - 102 - 99 = 101.0$$

Fourth experiment

Top of coil 2.

Deflection,

$$222 - 222 - 220 - 222 - 222 =$$

221.6

Fifth experiment

Top of coil 1.

Deflection,

$$325 - 325 - 327 - 325 - 330 =$$

326.4.

Sixth experiment

Top of coil 1 milli.

Deflection,

~~off scale. (New zero)~~

~~100~~) 445-451-452-443-

451.

448. 8

Seventh experiment

Coil flush.

Deflection, 462-464-467-

464-464. ~~4~~ 464. 2

Eighth experiment

Height from top of
armature 9.1

Deflection, off scale.

wire A page 54 the magnet was
15.3 cm. in length 0.9 cm
diameter

Distance of top of coil from top of magnet					deflection off scale
cm	cm	cm	cm	cm	
9.8	6.0	4.3	2.0	1.0	0.1 flunk 4.1
22	58	102	222	325	1145 1462
22	59	102	222	325	1145 1464
21	59	100	220	327	1152 1467
21	58	102	222	315	1145 1464
20	59	99	222	320	1151 1462
Means	21.2	58.6	101.0	221.6	326.4 1148.2 1464.2

A note in Engineering for Feb 22nd entitled "Telegraphy without metallic conductors" has attracted my attention and today with Mr Gower's assistance I carried on some experiments to ascertain how far the Telephone could be used in the manner indicated.

A battery B had its two poles connected to the earth through ~~key K~~ ^{key K} shown in fig 63. Ground connections were made on the one side by means of the ^{water} pipes and on the other by means of metallic strips buried in the garden. Mr Gower ~~operated the key~~ ^{opened & closed the circuit by the point}

While I made experiments in the garden. Two poles C and D were united by wires with a Telephone R as shown in fig 63. The poles C and D were then stuck into the ground in the garden at various points.

Very distinct sounds proceeded from the Telephone ~~when Mr Comp opened and closed the circuit at the point R~~ ^{during the manipulation of the key R by Mr Laver}. This happened in every part of the Garden.

A rheotome was then ^{placed at the point} substituted ~~for the key R~~ and sound was loudly audible in the Telephone. Mr Lavers' Telephonic Harp was then introduced into the primary circuit and every note was loudly audible in the Telephone R.

The loudness of the sounds produced from the Telephone seemed to depend somewhat upon the distance between C and D. When the distance was only about a foot no sound was perceived in the Telephone but when the poles were separated by more than a yard sounds were well marked. The distance between the water pipe and the earth plate shown in the diagram fig 63 was the length of our garden approximately about 50ft so that the points C and D were approximately in the space between the terminals of the primary circuit. Fig 64 gives a plan of the garden A and B show the terminals

of the primary circuit and the numbers indicate the position of the pokers - 1 no sound audible - 2 loud sound - 3 loud sound - 4 loud sound - 5 loud sound - 6 loud sound - 7 loud sound

Experiments were then made to test whether the sounds obtained this way are audible beyond the limits of our own garden.

An electric bell was substituted for the ~~telephone~~ ^{telephone} shown in fig 63.

The terminals of the bell circuit are shown at A and B fig 65 which represents a plan of the neighbourhood.

McGover and I then proceeded with our pokers and telephones to the open space beyond the end of the garden where an unfinished block of buildings is being erected. We each carried a poker and a coil of wire and a Telephone connected as in fig 66. I placed the poker C fig 66 into the ground just beyond the wall of our garden while McGover went to a distance of about 30 or 40 feet. McGover was just going to insert the poker D into the ground at his feet when I noticed that the sound due to the bell was perfectly audible in my telephone B when he held the poker D firmly in his hand.

Mr. Gower then stepped upon a plank and the sound ceased immediately. Upon lightly touching the ground with one foot sound was again audible.

The following observations were made with both forks placed on the ground. The points where the forks were placed are indicated on fig 65

- CD Distinctly audible
- CD 1 Ditto
- CD 2 Faint but audible
- CD 3 Audible
- CD 4 Loud
- CD 5 Ditto
- CD 6 Very faint
- CD 7 Louder
- CD 8 Much louder than in any previous exp.
- CD 8 Perfectly audible but not quite so loud as last
- CD 9 Very faint only audible by great attention

Entered this 10th April 1878 Y. I. W.

April 14th 1878

Experiment made Sunday 12th April.
Experiments were made this evening to ascertain whether the results noted yesterday could not also be obtained upon a small scale in a laboratory experiment by substituting water for the ground so that the conditions could be more fully investigated.

Lvs. nos. F and G fig 64 were connected with a Telephone 'T' through the

Support HE which could be turned and the wires D and E were connected with the coil C' which was placed against the coil C through which an intermittent current ^{from the rheostat R} was passed.

The secondary current was closed by placing the wires D, E in a basin of water and the sound of the rheostat was plainly audible from the Telephone T when the wires F, G were dipped into the water at any part of the basin. Upon turning the support HE the loudness of the sound from the Telephone was found to depend upon the direction of the wires F, G .

The experiments were not carried very far but as far as can be judged at present very slight audible effects were produced when the line joining F, G fig 68 was at right angles to the line joining D, E and that the maximum effect was produced when these lines were parallel as on the position I, G . The distance of D from E and F from G had a most marked effect. It seems as if the maximum effect was produced when the distance between F, G was the same as the distance between D and E . It seemed also that the greater the distance between D & E [the distance between F and G being increased in the same proportion] the better the effect.

Of course little reliance can be placed upon these observations until a careful series of experiments has been made verifying and amplifying the results. When a little sulphuric acid was dropped into the water all the effects noted above were obtained but the sounds from the Telephone were sensibly louder than when plain water was employed.

Entered this 14th April 1898 J.L.D.

April 18th 1898

Experiments made April 14th

Some time ago I made an experiment which surprised me at the time but which I have forgotten to note. The rheostat R fig 69 was placed on the laboratory and an intermittent current was passed through one of the wires of the cable A lying upon the floor in the study. Upon placing the Telephone 'T' to the ear the sound of the rheostat was plainly audible proceeding from the Telephone although the terminals B & C were unconnected and the instrument was at least 3 feet from the nearest portion of the cable. On bringing it near the cable A the sounds became much louder. When the terminals B and C were united by a wire no effect was audible from the Telephone at all. Today

there was a hailstorm accompanied by thunder and lightning and these experiments occurring to my mind I placed two Telephones one to each ear unconnected in any way and I was distinctly conscious ~~of~~ a ticking sound from the Telephones accompanied every flash of lightning. It seemed as if there was a double click but the opportunities for observation were so few that the only point that is absolutely certain is that ~~there~~ a noise from the Telephones accompanied each flash of lightning
 Entered this 18th April 1878 J.S.W.

April 23rd 1878

Experiments made April 19th

The experiment shown in fig 64 was repeated this evening. The two terminals of a battery circuit fig 70 were placed in a dish of water and the two terminals of a Telephone were dipped into the water at different parts. The primary circuit was made and broken by the pendulum of a clock.

A ticking sound was plainly audible on the Telephone when the terminals were placed in any part of the dish of water and the sound varied with the direction in which the coins were placed. Upon placing a sheet of tinfoil on the water A fig 70 no sound was audible

Notes concerning the law of
inverse Squares in order to facilitate
calculation of force emanating from
a centre. Take a force at distance
unity as 1 and express the forces
at greater distances by decimals

Distance	Inverse Sq	Decimal Value
1	1	1.000000
2	$\frac{1}{4}$	.250000
3	$\frac{1}{9}$	.111111
4	$\frac{1}{16}$	.062500
5	$\frac{1}{25}$	.040000
6	$\frac{1}{36}$	.027777
7	$\frac{1}{49}$	.020408
8	$\frac{1}{64}$	.015625
9	$\frac{1}{81}$	.012345
10	$\frac{1}{100}$	.010000
11	$\frac{1}{121}$	.008264
12	$\frac{1}{144}$	.006944
13	$\frac{1}{169}$	.005917
14	$\frac{1}{196}$	
15	$\frac{1}{225}$	
16	$\frac{1}{256}$	
17	$\frac{1}{289}$	
18	$\frac{1}{324}$	
19	$\frac{1}{361}$	
20	$\frac{1}{400}$	
21	$\frac{1}{441}$	
22	$\frac{1}{484}$	
23	$\frac{1}{529}$	
24	$\frac{1}{576}$	
25	$\frac{1}{625}$	


from the Telephone excepting when the secondary terminals were placed nearer to the primary terminals than the nearest edge of the sheet of tinfoil as at B fig 70.

The primary circuit was then kept closed. A distinct click came from the Telephone the moment one of the terminals touched the tinfoil but little or no sound was produced by its removal.

When one of the terminals was in contact with the tinfoil the contact on removal of the other terminal produced no sound. My object in placing the tinfoil in the water was for the purpose of noting the position of the Telephone terminals for max and min effects.

My idea was to press a wire down upon the tinfoil and leave a mark but as stated above no sound was audible from the Telephone when the primary circuit was made & broken so long as the terminals were over the tinfoil. I therefore had recourse to paper. A large piece of paper P fig 71 was placed in the water and the primary wires were forced through the paper at certain points B.C in the centre. One of the terminals of the secondary circuit was fastened at A and the other terminal was attached to a steel probe D which was placed in the water and moved about until a position was obtained where no sound was audible from the Telephone. The

probe was then pressed into the paper at that point leaving a mark. The result was that a pattern roughly shown in fig 42 was produced upon the paper in dotted line. In every position of the terminal H fig 41 a closed curve was formed round one of the terminals B.C. so that when the probe D was placed upon any part of the curve and the point A upon any other part of the curve no sound was produced from the Telephone.

In order to get the proportion of the curves a sheet of paper was prepared as shown in fig 43. A horizontal line AB was drawn across the paper in pencil and dots 1.2.3.4.5.6.7c were made upon the line at distances of 5 cm. apart. The primary coils were placed upon the points 4.5 and the fixed terminal of the primary circuit was placed upon the point 3. The curve traced by the probe is shown at C fig 43. The curve cut the straight line joining 4.5 just one third from the point 4. When the fixed terminal was placed upon the point 6 the resulting curve D cut the line 4.5 at a point $\frac{1}{3}$ of the distance from 5 and all the other curves drawn when the fixed terminal was placed upon the other points 1.2.3.4.5.6.7c cut the line joining 4.5 between the first and second dots. This original paper is preserved & marked. At date April 19 1898
 curves drawn  Other papers

were prepared in which the terminals 4.5 instead of being 5 cm. apart were 10 & 20 cm apart. These papers are preserved & marked B & C respectively, dat. 19 April 1898. It was uniformly found that when the fixed terminal of the secondary circuit was placed upon a prolongation of the line joining the primary terminals at a distance equal to that between the primary terminals the curve produced by the probe cut the line uniting the primary terminals at a distance of just one third of its length.

Entered this 23 day of April 1898 J.W.

April 24th 1898

Experiments made April 24th
Upon examining the curves made yesterday shown roughly in fig 72 and preserved on papers A, B and C I was struck by the fact that the distances A.D. B.D fig 74 were in the same proportion as the distances A.C B.C and that in both cases the points C and D seemed exactly true as far from the terminal B as they were from A and I found that the same seemed to be true of every point upon the circle.

The following are

To ascertain whether such a theory could give a figure similar to that shown in fig 72 distances from A were

assumed and the distance from B calculated as double these. The following numbers were taken

Distance from A	Distance from B
30	60
31	62
32	64
35	70
40	80
45	90
50	100
60	120
70	140
80	160
85	170
90	180
100	200

These points were measured off by compasses and a curve was formed round A similar to the curve shown in fig 74. By assuming other distances from A and a proportional distance from B other curves were drawn round A similar to the curve shown in fig 72. The original paper is preserved and marked A April 20th 1848. The only difference between the curves so drawn and those obtained by experiment is that the former are circles while the latter seem to partake of ellipses but the elliptical shape of the curves in the latter case may be due to the imperfection of the experiment. Supposing

a current to travel along the path
 ADB fig 74 and the potential of the
 point D the ascertained and
 next let a current be supposed
 to travel along the path AEB it is
 evident that the potential of the point
 E would be the same as at the
 point D if the resistance of AE is
 to EB as AD is to DB

Experiments made April 23rd

The series of lines of equal potential
 drawn from calculation were completed
 last night and tested them this
 morning by placing the paper in water
 and holding the Telephone terminals
 upon different points of the lines.

The lines of no current however did
 not seem to coincide precisely with
 the lines drawn upon the paper &
 it really seemed as if the curves of
 no current were elliptical instead
 of circular. To get the proportions
 more fully developed Mr Warner and
 I went out this afternoon and
 repeated the experiments upon a large
 scale only instead of using water
 we employed the earth itself

Two poles A & B fig 75 were
 placed on the ground and were made
 the terminals of a battery. Mr Warner
 opened & closed the circuit at the point
 K. The pole C was inserted on the

ground at a certain distance from B and the circuit from it through a Telephone was completed by placing the potter D in the ground.

The terminal C ~~being~~ fixed D was shifted from place to place and the points of no sound observed.

The distances of such points were taken from A & B.

The following are the measurements taken

1st Exp. Distance of A & B. 5 metres
 Dist^{ce} of points from A. 183 . 214 . 200 . 215 . 228 . 235
 255 . 275 . 305 . 475 . 393 . 475 . 500
 Dist^{ce} of points from B 320 287 318 365 358 346
 427 . 410 . 535 . 784 . 775 . 934 1000

2nd Exp.

Dist^{ce} of A B 19.78 m Dist^{ce} of C B 19.78
 Dist^{ce} of B D 712 812 953 1052 1107 = 927.2

3 Exp.

Dist^{ce} of A B 39.56 m Dist^{ce} of B C 39.56
 — " — B D 2000 . 2876 =

over

An experiment was tried as shown in fig 46 the poles A B were inserted into the ground at a distance of 39.55m. apart. The pole C was 39.55m. from B and the pole D was 1 m from B. Under these circumstances conversation was carried on by means of the Telephones T. T' as freely as though they were on the same circuit. Mr Warner sang a continuous musical note into the Telephone T and listened at T' gradually removing the pole D further and further from B. The sound of Mr Warner's voice was perfectly audible when the pole D was at a distance of about 3 or 4 m from B.

Entered this 24th April 1878 J.L.M.

May 1st 1878

Experiments made 27th April

Experiments were made today on the river Thames at Kew. Some tinfoil was attached to copper wire and thrown into the water at A fig 47 and a pole was inserted into the ground at B. Distance between A & B was about 9 metres. A Telephone circuit was completed in a similar manner at C & D. Distance between A and C and B D was about 6 metres.

Mr Warner opened and closed a battery

circuit at the point K and sounds
 were distinctly audible in the Telephone T'.
 The Telephone circuit was then removed
 to F & F'. Distance between A & E
 E & F' about 20 metres. Under these
 circumstances little or no sound was
 audible from the Telephone when the
 battery was opened & closed. The
 terminal B was then removed and
 placed at B' making the distance
 between A and B' metres. The
 opening and closing of the battery circuit
 was then very distinctly audible from
 the Telephone. The battery terminal
 was then further removed to the point
 B² and the Telephone circuit was
 removed to G & H. Distance
 between A & B distance between
 G & H distance between
 Telephone circuit and battery circuit
 about 45 metres. Under these circumstances
 the opening and closing of the battery
 circuit produced very distinct sounds in
 the Telephone. The Telephone circuit
 was then removed to the other side
 of the river as shown in fig 78.
 The terminals A & B of battery circuit
 were about 45 metres apart and the
 terminals C & D of Telephone circuit
 were about the same distance apart
 on the other side of the river. The
 breadth of the river was as nearly as
 could be judged by the eye about
 45 metres across over which the terminals

A C D B seemed to form nearly a square. Under these circumstances the opening and closing of the battery circuit at the point K occasioned very distinct sounds in the Telephone on the other side of the river. Mr Warner introduced a Telephone at the point K and sang into the instrument. The pitch of the voice was very clearly discernible in the distant Telephone and so when sang into the Telephone Mr Warner could hear the sound of the voice, but was uncertain whether it came through the instrument or through the air.

Entered this 1st May 1878 J. W. D.

11th May 1878

Experiments made 30 April
Went today to Muckingham to continue experiments on the river Thames. Four pieces of metallic foil A B C D fig 79 were taken as water terminals each piece of foil being 9 inches in breadth and 12 feet in length. The Distance between A & B was (60 paces) and that between C & D about the same. The breadth of the river was unknown but was approximately about $\frac{2}{3}$ of the distance between A & B. The Telephone F was placed on one side of the river and the Telephone B on the other. A battery G consisting of three Le Clanche elements was placed in one circuit, as

shown at fig 49

Mr Warner spoke & sang into the Telephone F and I listened at F' . It was with great difficulty I could be sure of any sound proceeding from the Telephone F' but it is certain that a slight sound was audible & when Mr Warner opened & closed the circuit at F distinct sound was audible from the Telephone F' but the sound was not nearly so loud as that heard at New & noted on page 80 fig 48. This seems very extraordinary when we consider the size of the water terminals. Mr Warner removed the terminal D fig 49 and simply placed the end of the conducting wire in the water and upon opening and closing the circuit at F sound was still audible from F' but very much fainter than before.

This evening in order to test the influence of the size of the water terminals upon the sound the experiment shown in fig 80 was made. A, B, C, D are the terminals of battery & Telephone circuit immersed in water & F, F' are two pieces of tin foil also immersed in water.

It was found when the terminals A, B or the terminals C, D were placed upon the pieces of tin foil the sound from the Telephone was markedly increased. It was evident however that it was much more advantageous to increase the size of the battery terminals than

of the Telephone terminals and the sound proceeding from the Telephone was much louder when the battery terminals were placed on the tin foil. A distinct click proceeded from the Telephone when any of the wires A, B, C or D touched one of the pieces of tin foil and this quite independently of the rheotome.

The terminals A, B were removed from the water and contact was alternately made & broken between C & D. A sound was distinctly audible in the Telephone when contact was made & broken but the sound audible when contact was made was much louder than when it was broken.

Entered the 14 May 1848. J. 210.

May 15th 1848

Experiments made May 6th 9th & 10th

To test the influence of the size of the plate circular disks of tin were cut out the radii of the circles being 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. and 14 cm. The nature of the leap

will be understood by reference to fig 81. The plate of tin P was laid upon a table and a magnet N with coil attached was placed upon the centre of the plate. The deflection of the Galvanometer G was noted upon sudden removal of the magnet N. The magnet was ^{so} far distant from the Galvanometer that its influence directly upon the needle may be neglected. It was found upon moving the magnet when there was no circuit with the Galvanometer that the needle was not deflected perceptibly. The deflections obtained are as follows

6th May 1878 = Deflections -

1 cm plate	72	70	71	72	70	Mean	71
2 - " -	160	165	164	163	170	- " -	164.2
3 - " -	205	201	203	200	200	- " -	201.8

Deflections with magnet pressed hard against plate

11 cm plate	262	262	260	262	264	Mean	262
3 - " -	245	241	237	238	239	- " -	240
3 - " -	240	241	238	241	240	- " -	240
2 - " -	192	182	188	182	180	- " -	184.8
2 - " -	170	172	175	170	180	- " -	173.4
5 - " -	260	245	258	270	252	- " -	257
5 - " -	248	262	260	260	275	- " -	261
4 - " -	261	240	253	240	262	- " -	257.2

Experiments made 9th May 1878.

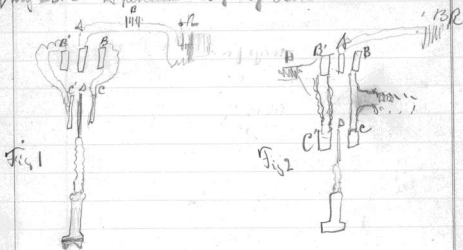
2 cm. plate	191	193	194	195	191	Mean	193.4
3 - " -	249	245	250	252	250	- " -	249.2
4 - " -	272	272	272	272	272	- " -	272.0
5 - " -	283	277	283	285	283	- " -	282.2
6 - " -	289	289	291	292	287	- " -	289.8

May 10th Deflections continued

2 cm plate	172	165	168	160	168	Mean	166.6
3	222	225	230	225	225	- " -	225.4
4	235	238	238	242	242	- " -	235
5	268	250	245	260	262	- " -	257
6	260	260	260	265	270	- " -	263
7	282	250	250	282	252	- " -	263.2
7	280	282	285	278	278	- " -	280.6
8	282	292	289	292	289	- " -	288.8
9	292	290	293	293	285	- " -	290.6
10	300	310	309	310	292	- " -	304.2
14	318	309	306	306	312	- " -	310.2

1 cm 1 in plate	72	1 cm plate Russia Iron	62
2 cm 1 in plate	185	2 cm plate Russia Iron	152
3 " "	220	3 " " "	198
4 " "	239	4 " " "	218
5 " "	252	5 " " "	222
6 " "	270	6 " " "	235
7 " "	275	7 " " "	236

July 23d - Experiment - by J. J. Oak



Pass from Rejection B' information current through A
 Obs. Induced current in B & C
 Pass from B' B induced current through C' & C
 Obs. Induced current in D
 Connect telephone with D.

No 1 Obs. sound effects in telephone ^{injected} related to rejection.

Make D equidistant from C & C'.

a- Obs. Almost Silence. Inf. Induced current nearly balanced

b- " Silence

Make D ^{also} unequal distance from C & C'

Obs. sound of greater or less intensity

c- All these sounds are Composites; i.e. composed of a fundamental & overtones

July 24th Thurs AM

Insert between B & C or B' & C' Rejection as Fig 2.

Before any resistance between D midway from B & D.

Silence (?)

No 2 After " " " " " "

Faint sound

Move D toward C'

Sound louder

" " " C for a

Sound less & harsher

No Silence

a- When D is moved toward C a harsh sound is obtained added to the fundamental

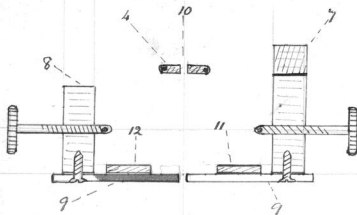
b- When D is moved toward C' a velocity sound is obtained

c- No Silence obtained

d A diff of 100-200 ohms will cause the diff of Harsh & velvet

e The amount the Resistance between D & C must be small for best results

Fig 4



(Vertical section 7)
Dotted Line EF Fig 1.

Fig 2 Blun B' + C' insert a large cone helix

Before inserting Helix has D. at first of silene -

Insert Helix ^{1 cm} _H Dremamija position Sound obtained

More & insert C' a very little

Almost silene. Uphectones

" " " " more Sound nothing good

With D. at first of silene for one helix, ^{insert helix only} ~~insert helix only~~
^{little by little,} ~~insert~~ ^{resistance} between B+C

Insert 400

Up to 400 no effect -

" 1000

A part of the ^{slight increase} and the fundamental

" 3000

A great change to fundamental

" 4000

Still more

With the helix at H. 1000 mm

at Rhinoid produces sound with D. at neutral part;

Run large cone, cone d. helix, has D. at neutral part.

Slight increase

insert resistance up to 30 ohms

No increase

Insert 30 ohms

Has small part of iron in helix

insert up to 40 ohms resistance

No increase

Insert 70

increase

Place long Bar with Helix 1000 Helix open

No increase

Insert 200

increase

Connect end of helix no. 2, up to 50

No increase

Insert 50

increase

Connect the Helix Cell with Helix No. 2

Up to 100 by Current passing in way

No increase

Insert 100

increase

Up to 100

Current passing in way

No increase

Insert 100

increase

N.B. Refer to the above experiment with D. at silene with Helix ^{at H.} _{at H.}

The increase in sound is the effect of the current -

causing the sound to be produced. I am not sure whether the sound is caused or not. I think not.

Thurs P.M. July 24th



Place P at point where the filament shows least sound when large Helix and C are connected between B' & C'

Insert resistance between B & C up to 100 ohms

Insert 100 ohms

" 200

" 500

With Helix in circuit 90 ohms

Remove from C

Insert resistance up to 30 ohms

" 30 ohms

Place small iron in helix

up

Insert resistance up to 70

up

Place 70 ohms resistance

Place 70 ohms resistance

Insert large C

Insert resistance up to 100

Insert 200

Insert large C and add resistance up to 100

Add 70 ohms

Connect wires of helix to C

add up to 70

" 70 ohms

Pass current in circuit around Helix 2

Pass current in circuit around Helix 2

No Change

Sound not faint

Sound increased

Sound increased

Sound slightly

Sound slightly

Sound slightly

No Change

Sound louder

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

No Change

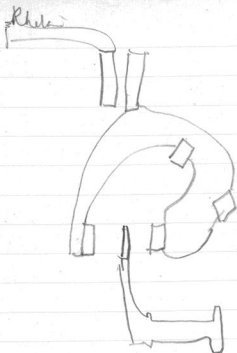
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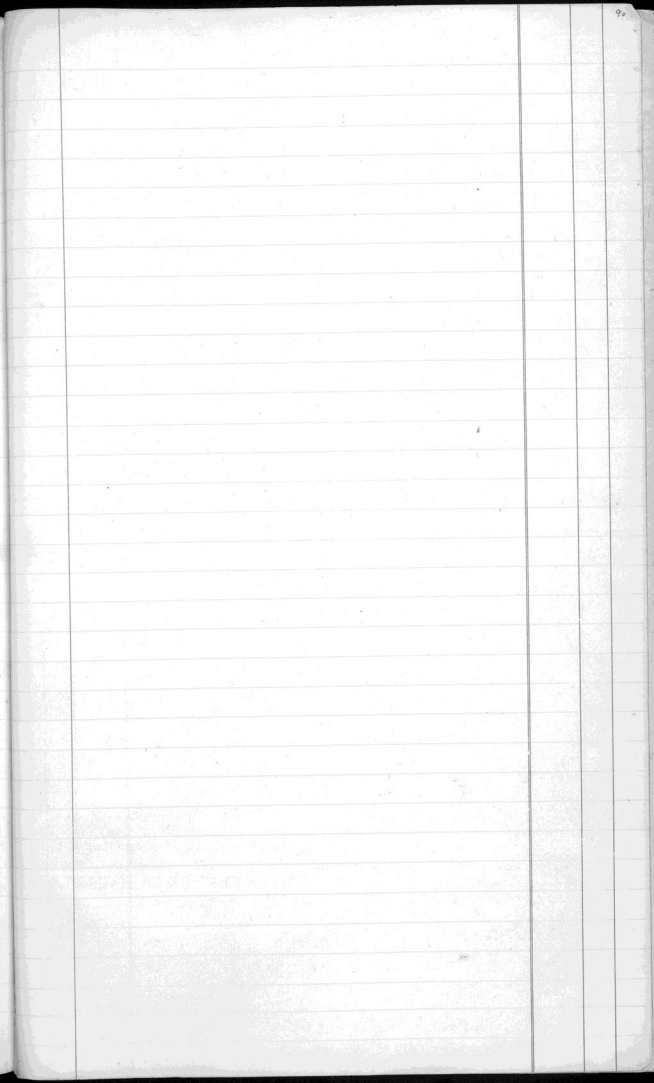
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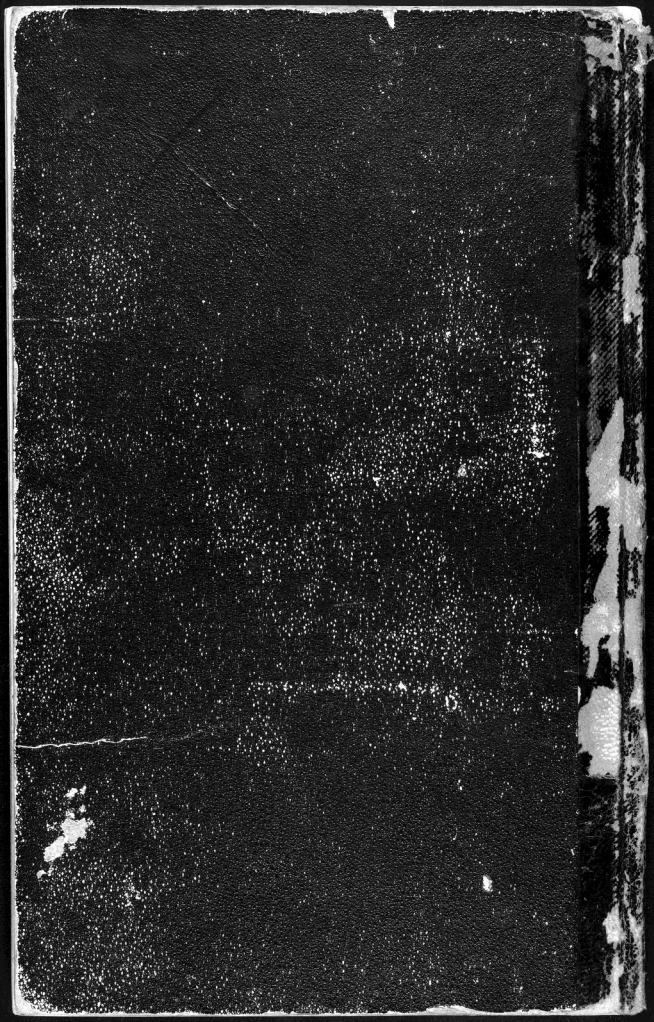
No Change

No Change

No Change







Leiter-Kassette Body-Examination
 dated 7/11

Leitungs-Schneid-Apparat

Prüfung 8. April 1881

